FINAL REPORT

MARINE SEISMIC SURVEY

JONESPORT, MAINE

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Prepared for: U.S. Department of the Army
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1.0 INTRODUCTION

During the period between July 6, 1979 and July 8, 1979 Ocean Surveys, Inc. (OSI) acquired seismic reflection profile data within an area of Sawyer Cove, Jonesport, Maine as requested by the New England Division of the U.S. Army Corps of Engineers.

The specific objective of this survey was to outline the morphology of the bedrock surface buried beneath the unconsolidated sediments of Sawyer Cove. This information was acquired to aid in determining the feasibility of constructing a breakwater across the mouth of the cove.

2.0 EQUIPMENT EMPLOYED

The equipment employed for this survey consisted of three different systems integrated to allow acquisition of bathymetric, seismic reflection, and precise positioning data in the specified area. The individual systems are described below.

2.1 Bathymetric

Precision water depth measurements were acquired employing a Ross Laboratories model 400 echo sounding system consisting of a 100 KHZ transducer with a 5° x 10° beam pattern and a graphic recorder equipped with Ross's "fine line" signal processing to record small scale bottom features. The system additionally possesses tide/draft compensation and sound speed calibration capability to allow calibration for local water mass sound speed. Instrumentation accuracy of the Ross 400 is 0.5 percent of indicated depth ± one inch. A specification sheet is enclosed in Appendix A.

2.2 Seismic Reflection Profiler

Seismic reflection data was obtained employing an OSI model 300 high resolution boomer system. This system consists of an EG&G/OSI high resolution boomer transducer mounted on a "sled", an OSI 300 Joule Boomer/Sparker energy source, an OSI 10 element receiving array with a one-foot spacing between each hydrophone element, a Krohn-Hite band-pass filter, and a Gifft 4000-T wet paper graphic recorder. This system has the ability to discriminate bottom and sub-bottom reflectors with a resolution of one to two feet. A specification sheet for the OSI Boomer system is included in Appendix A.

2.3 Navigation

Navigation, vessel control and post operational trackline reconstruction were accomplished employing a Cubic "Autotape" DM-40A dual range electronic positioning system.

This system is comprised of three components; two responder units and an interrogator unit. Range measurements are obtained by microwave phase comparison between the shipboard interrogator and each of the two shore based responders providing extremely accurate ranges between the vessel and the shore stations. The two ranges are automatically displayed, in meters, by the onboard interrogator at a one second rate. The accuracy of the indicated vessel position at each one second "fix" is nominally $\pm$ 1.0 meters and is virtually unaffected by atmospheric conditions. A specification sheet on the Cubic DM-40A "Autotape" is included in Appendix A.

2.4 Vessel

All instruments and recorders, except the "Autotape" responders, were mounted on or towed from OSI's 21-foot diesel powered R/V Ready. This vessel's shallow draft, large enclosed cabin, and outdrive propulsion made it ideal for operations at this project site.

3.0 FIELD PROCEDURES

3.1 Horizontal Control

The locus of all points equidistant from an "Autotape" responder unit is defined by a circle centered about the responder location. Based upon a plot of concentric range arcs at 50 foot intervals about the survey point "NET" (R_1), it was determined that 19 tracklines would be needed to cover the survey area. Ranges measured from the second responder (R_2) located at survey point "Red Pipe" would "fix" the position of the vessel along the arcuate trackline.

Prior to field data acquisition, the section of the range arcs representing the tracklines within the survey area was determined by measuring the R_2 ranges to the points on the arcs where they intersected the survey boundaries. Sufficient extensions to each end of the tracklines outside the survey area were included to insure that structural trends within the area would be adequately defined.

During operations, the helmsman positioned the vessel on the desired trackline by steering the vessel away from R_1 until the required range was displayed on the interrogator unit. The vessel was then "Conned" along the track by steering so as to maintain a constant range from R_1. At intervals of approximately 15 seconds, sequentially numbered position fixes along the trackline were taken by recording both R_1 and R_2 range measurements. At each fix, both seismic and echo sounder records were annotated to correspond with the numbered navigational fix.

3.2 Vertical Control

Vertical control required to reference all data to the Mean Low Water (MLW) datum was accomplished through two efforts. The first involved calibration of the depth sounder for local water mass sound speed and the second, monitoring the tidal heights relative to Mean Low Water during the data acquisition period.

3.2.1 Echo Sounder Calibration

The Ross Echo Sounder was calibrated for local water mass sound speed by performing a bar check at a water depth representative of general water depths in the survey area. A bar check was performed prior to commencement of survey operations each day with subsequent bar checks made during the day to verify consistant water mass sound speed and retention of sound speed calibration.

3.2.2 Tidal Measurements

In order to relate the echo sounder data to the desired Mean Low Water datum, the recorded depths must be corrected for actual tidal height at the time of data acquisition. Tidal heights were measured by installing a tide staff at the public landing pier in Jonesport. The staff was 24 feet long and marked in increments of 0.1 feet. Water levels, measured on the staff, were referenced to MLW based upon the established MLW reference of the installed staff.

Tide readings were taken approximately every 20 minutes with more frequent readings taken near the maximum and minimum of each tidal cycle.

3.3 Operational Procedures

Operations were based out of Jonesport, Maine where the vessel was berthed at the public landing.

Each day before actual survey operations commenced the "Autotape" responders were deployed (R_1 at "NET", R_2 at "Red Pipe"), and the echo sounder calibrated. Bar checks were normally taken at a depth of 30 feet. ?

During survey operations both the "sled" and the hydrophone array were towed at a distance of 25 feet astern off the port and starboard sides, respectively. At this distance, the source-receiver pair was out of the vessels wake and essentially uncoupled from vessel motion.

Of the 19 runs performed, 12 were run from west to east and seven run from east to west. The direction of the run was choosen so that the deepest water along the trackline would be at the beginning of the run. This procedure was advantageous as it allowed better definition of the bedrock trace and assured higher quality records without mid-run gain adjustments.

4.0 DATA

4.1 Data Reduction

The first step in the data reduction involved reconstruction of the survey vessel's tracklines. This was accomplished by plotting the recorded navigational fixes on a flat sheet with the two sets of range arcs, one for each responder as a grid overlay. Each fix was labeled with the corresponding fix number recorded on the echo sounder and seismic records.

Water depths were obtained from the echo sounder records by picking maxima, minima, and inflection points along the bottom profile. These recorded depths were, in turn, corrected for both sound speed calibration and tidal heights prior to final tabulation.

Reduction of the seismic data was accomplished in two steps. First, mylar overlays were attached to the records on which the bottom and bedrock profiles were traced. Since precise water depth measurements were obtained from the echo sounder, the bedrock trace was picked only relative to the bottom reflection by picking the travel time interval between the bottom and bedrock reflections as scaled off the vertical dimension of the seismic records.

The second step in this process involved conversion of these travel time measurements to actual depths below the bottom. The "time-to-depth" conversion was made by multiplying the measured travel time by the propagation speed of a compressional wave through the sediment.

As an approach to determining a realistic sound speed value for the sediments in the survey area, the following data was considered. Bore holes drilled in the area revealed that the unconsolidated materials are composed of sandy silt and clays with some traces of organic materials and coarser grained sediments. Since none of the holes encountered bedrock, knowledge of the sediment type represented the only information on which to base an estimate of the compressional wave speed through the sediment.

In his compendium volume on the physical and engineering properties of marine sediments, E.L. Hamilton (1969) indicates that a speed of 1578 meters/sec. (5177 feet/sec) is characteristic for a sediment composed of 33 percent sand, 41 percent silt, and 26 percent clay. This sediment mixture approximates that found at the survey site except for the presence of organic material which will tend to decrease the celerity of wave propagation.

Following consideration of the above data we feel that an average sound speed of 5150 feet/sec. is a reasonable estimate for the speed of compressional wave propagation within sediments in the survey area. Correspondingly computation of the unconsolidated sediment thicknesses existing between the bottom and the bedrock reflections have been calculated using an assigned compressional wave speed of 5150 feet/sec. These computed thicknesses were, in turn, added to the measured water depth at each point giving the resulting depth to bedrock which were then plotted on the prepared control sheet and contoured at a five foot depth interval.

4.2 Data Interpretation and Presentation

Drawing #71985-2-A is a contour sheet of the inferred bedrock surface at a horizontal scale is one inch = 50 feet. The contour interval is five feet. The term "inferred bedrock" has been employed as there were no bore holes drilled to bedrock which precludes positive control on the seismic data. This terminology also was adopted as some sections of the bedrock traces were faint and/or difficult to follow. Although not a severe problem, both bottom multiples and the horizontal distortion of the records as a result of the slow boat speeds required within the small boat anchorage area made record interpretation more complex.

Although every attempt was made to secure complete coverage, there are two small data gaps in the survey area. The "gap: in the northwestern part of the survey area (approximately N 25500, E 736250) occurs where the vessel was required to make numerous turns to avoid moored boats. This maneuvering introduced a high level of noise in the records and substantially reduced data quality. The second area was in the vicinity of Henry Point where extremely shallow water in an area with an irregular bottom made vessel and seismic equipment operation impractical. On the positive side, however, both gaps appear to be in areas where the bedrock appears to be relatively flat and at shallow depths.

As mentioned above, a contour interval of five feet has been selected. This decision was made to provide a detailed presentation of data acquired during this survey. The major structural trends in the area are more easily observed, however, by examining the bedrock at a 20 foot contour interval. To highlight these trends, beginning with the 10 foot contour, a heavier line has been used for each deeper contour line at a 20 foot interval, i.e., 10, 30, 50, 70, etc.

Based upon a review of drawing No. 71985-2-A, it appears that areas where the bedrock occurs at shallow depths (less than 30 feet below MLW) exist only in the northeastern and northwestern portions of the survey area. These bedrock "highs" are separated in the central portion of the site by a gap that slopes into depressions both to the north and to the south. The gap narrows to approximately 100 feet between the 30 foot contours, in an east-west direction, at a point approximately 250 feet southwest of Henry Point.

Although a case can be made from the seismic data for the existance of a subsurface bedrock dike as has been variously proposed in this area, a continuous, high relief, elongated structure is not clearly evident. The possibility exists that the steep slope along the southern margin of the survey area may represent the flank of such a structure but further data would be needed north of the survey area to investigate this possibility.

If confirmation of the character of the bedrock features in this area are of specific importance to the breakwater construction, it is suggested that final site evaluation should be based upon additional seismic data acquired to the north of the present survey area coupled with conformation borings at locations which can be selected based upon the results obtained during this reconnaissance survey.

REFERENCES

Hamilton, E.L.; 1969

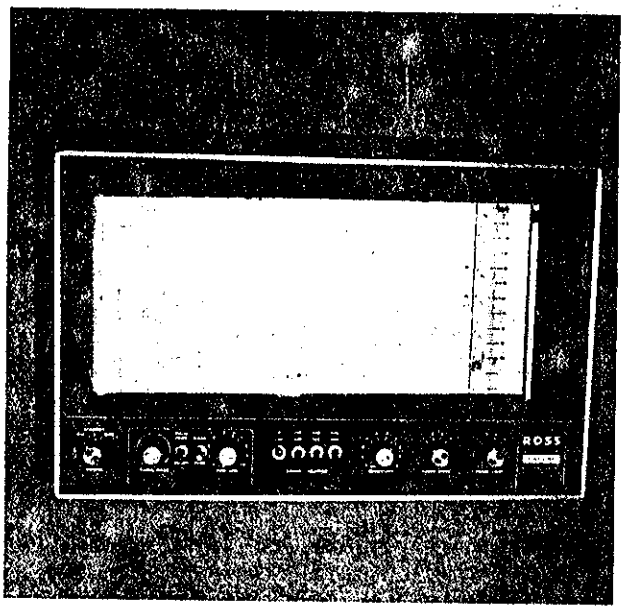
Sound Velocity, Elasticity, and Related Properties of Marine Sediments, North Pacific

Volume I, page 12.

Naval Undersea Research and Development Center Report NVC TP 143

APPENDIX A.

EQUIPMENT SPECIFICATIONS



BOTTOM PROFILING

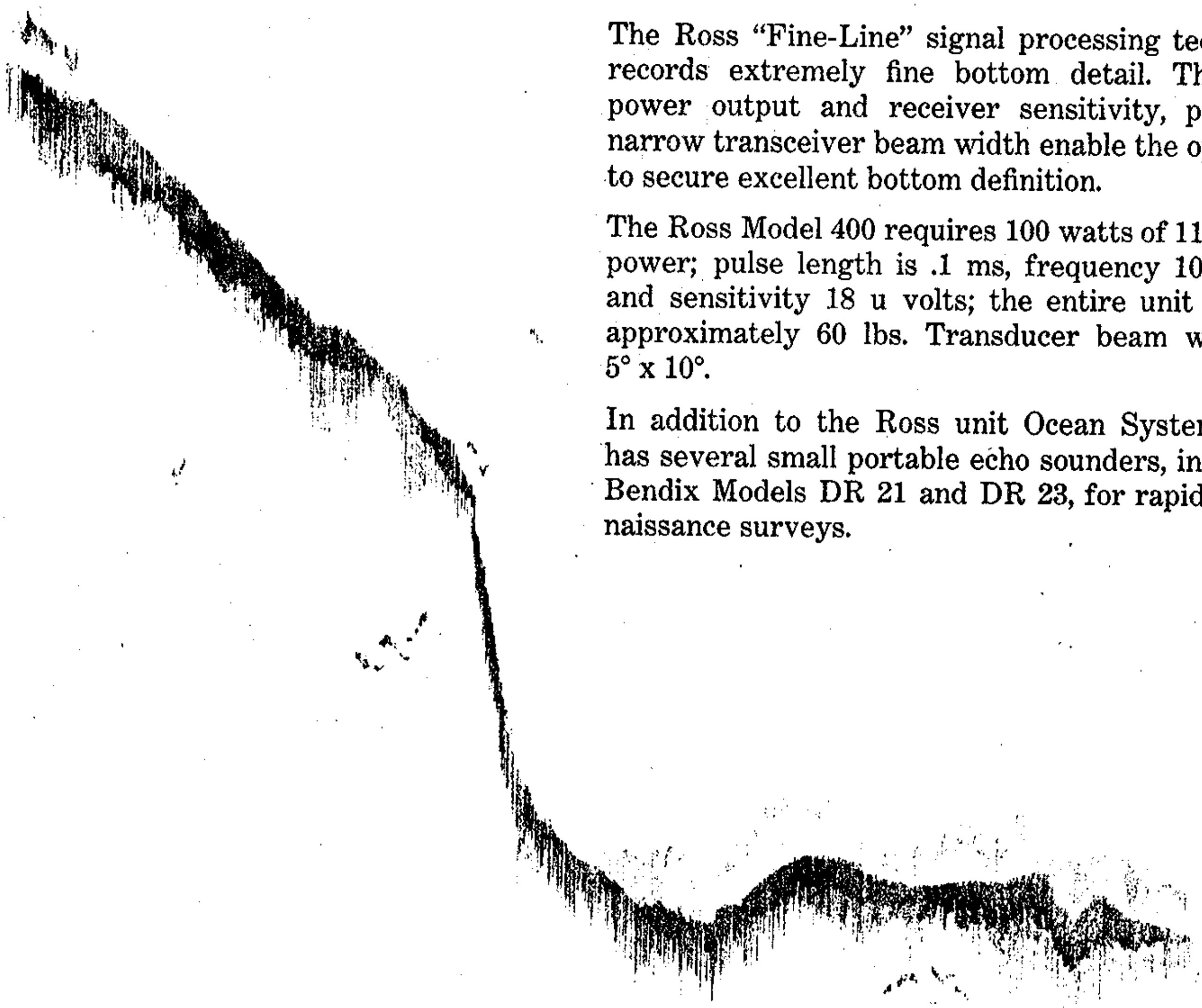
ECHO SOUNDING SYSTEMS

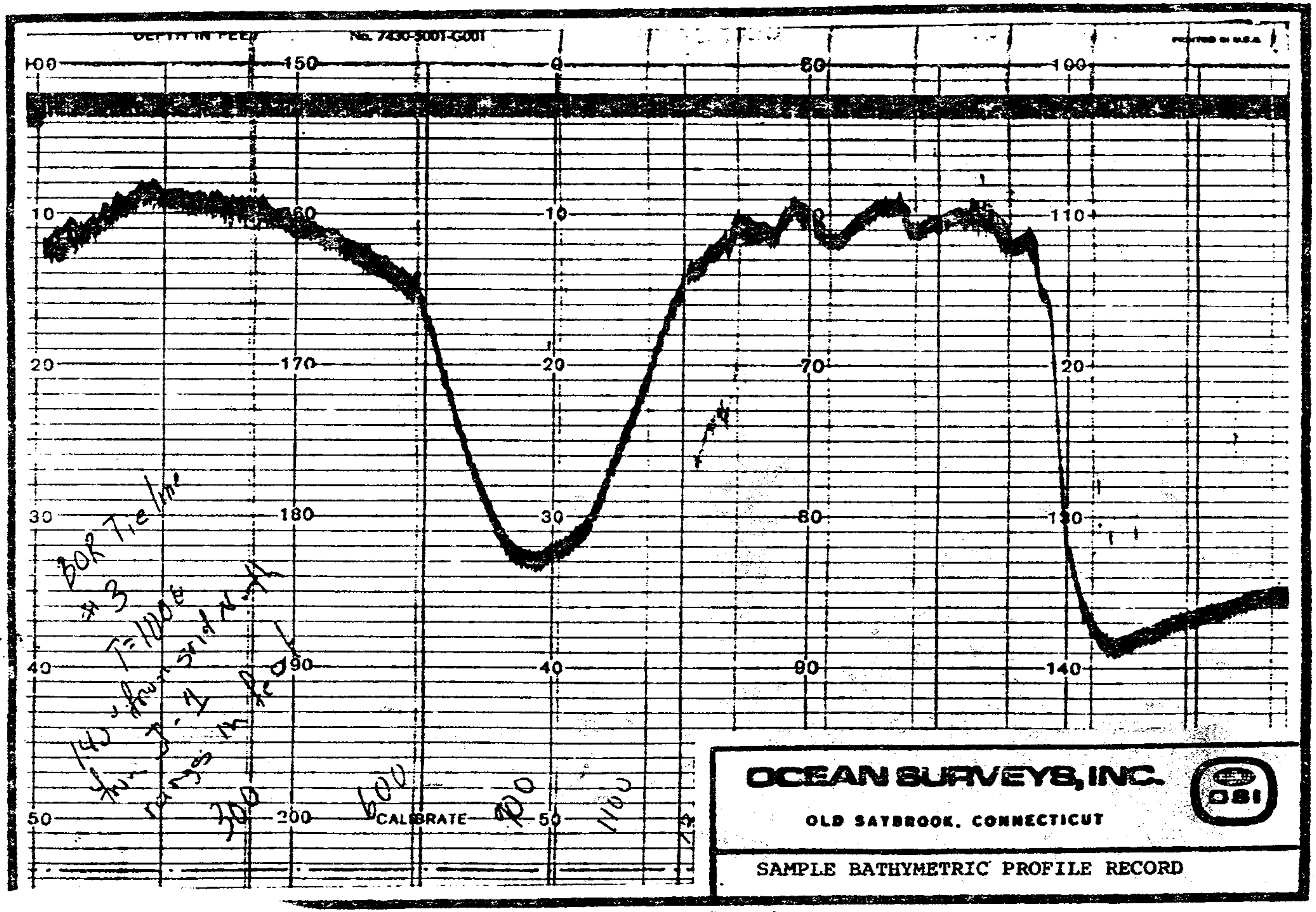
For accurate bottom profiling, Ocean Systems utilizes the Ross Laboratories' Model 400 "Surveyor." This unit, consisting of a recorder, electronic chassis, and transducer, is designed for high accuracy in shallow water. Direct readings to 400 feet are obtained on the first sweep, while in-step phasing permits reading beyond 400 feet on the second revolution.

The Ross "Fine-Line" signal processing technique records extremely fine bottom detail. The high power output and receiver sensitivity, plus the narrow transceiver beam width enable the operator to secure excellent bottom definition.

The Ross Model 400 requires 100 watts of 115 v. AC power; pulse length is .1 ms, frequency 100 KHz, and sensitivity 18 u volts; the entire unit weighs approximately 60 lbs. Transducer beam width is 5° x 10°.

In addition to the Ross unit Ocean Systems also has several small portable echo sounders, including Bendix Models DR 21 and DR 23, for rapid reconnaissance surveys.

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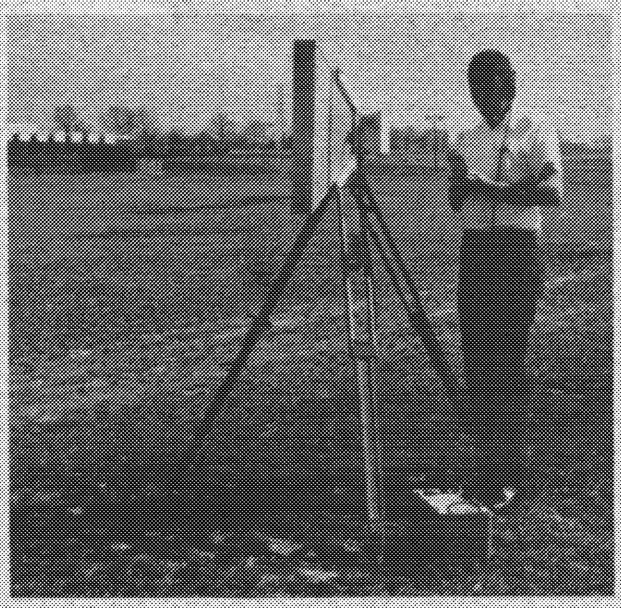

NAVIGATION

MICROWAVE PRECISION NAVIGATION AND POSITIONING SYSTEM

To provide accurate navigation and positioning at distances up to 50 miles from shore, Ocean Systems employs the Cubic DM-40 "Autotape" system. This equipment utilizes microwave phase comparison between the shipboard interrogator and each of two shore responders to provide accurate ranges between the vessel and the shore units. Range measurements are automatically displayed, in meters, on the ship at a rate of one per second. Accuracy is essentially ± 1 meter and is virtually unaffected by atmospheric conditions. The system is completely automatic and self-calibrating and can be used to measure its own base line distance between the shore stations.

The entire system is lightweight and portable, requiring a minimum of shipboard or shore space. Power can be furnished by one storage battery at each unit. Included in the system is a built-in radio communications link.

SPECIFICATIONS

Operating Range: 50 Kilometers between antenna ½ power points over radio line-of-sight

Probable Range Accuracy: 50 cm + 1:100,000 X range

Operating Frequency: 2900 to 3100 mcs.

Transmitted Power: 1.0 watt maximum

Antenna Beam Width: (½ Power)

Responder (Horn)	60° Horizontal 10° Vertical
Interrogator (Omni)	360° Horizontal 10° Vertical

Display: 5-digit numbers to 9999.9 meters for both ranges.

Display Rate:
- Automatic: 1 per second
- External: On manual or electronic command: 1 per second maximum

Data Outputs: 20 line binary-coded decimal 1-2-4-8 for each range.

Communications: Integral two-way communication from interrogator to all Responders.

Range Resolution:
- Automatic and fine: 10 centimeters
- Intermediate/Coarse: 1 meter

Physical Characteristics:
- Interrogator: 11" H, 20.5" W, 21" D, 55 lbs.
- RF Assembly: 4" H, 7.5" W, 13.5" D, 15 lbs.
- Responder: 8" H, 14" W, 11" D, 35 lbs.
- Horn: 39" x 24" x 5½", 20 lbs.
- Omni: 18" long, 1.75 dia., 4 lbs.

Power Requirements:
- Interrogator: 70 watts, 12 vdc.
- Responder: 35 watts, 12 vdc.

SEISMIC PROFILING

BOOMER

Ocean Systems' high-definition boomer system permits profiling of as much as several hundred feet of sub-bottom material in moderate water depths. It has been specifically designed to present excellent stratigraphic detail with modest equipment size, weight and power requirements. Power output is 200 joules at 4 pulses or less per second. Normal profiling speed is 5 knots with a maximum of 10 knots.

The system consists of a precision 19" graphic recorder with amplifiers; a filter unit; a combination power supply, energy storage, and trigger unit; a multi-element eel hydrophone; and a special boomer transducer. The total system weight is approximately 350 pounds.

SPECIFICATIONS

RECORDER

Chart Width: 19", wet paper type
Sweep Speeds: 1/16 second thru 2 seconds
Sweep Accuracy: .005%, stability .001%
Scale Lines: 20 per sweep
Time Breaks: At 30 seconds and 5 minutes
Weight: 70 lbs.
Power Requirement: 70 watts, 115 v. AC
Amplifiers: Selectable up to 80 db, TVG optional
Magnetic Tape I/O: Provision for recording and playing back raw or conditioned signals. Furnishes duplicate records and allows optimum signal conditioning to be accomplished in the laboratory.
Filter: 2 section variable active filters, 20 Hz to 2 MHz; 24 db/octave.

POWER SUPPLY/ENERGY STORAGE AND TRIGGER UNIT

Output Power: 200 joules
Output Voltage: 3800 volts
Max. Pulse Rate: 4 per second
Trigger: Thyratron
Weight: 80 lbs.
Power Requirements: 3.8 KW, 115 v. AC

BOOMER TRANSDUCER:

Eddy Current Displacement type based on standard EG&G Mod. 261, specially modified by OSI to eliminate rebound and cavitation pulses.
Pulse Length: Less than .5 ms.
Mounting: Catamaran
Weight: 120 lbs.

HYDROPHONE:

20 element (10 pairs) in linear (eel) configuration.
Length: 13 feet overall
Diameter: 2"
Buoyancy: Neutral
Preamplification: Built-in
Power Requirements: 12 v. DC (supplied from recorder)

NOTE: A sparker electrode is available with the unit which can be substituted for the boomer transducer, providing low power sparker profiles.